Summary Report for the 2014 Photo Interpretation and Floristic Reclassification of Mt. Tamalpais Watershed Forest and Woodlands Project

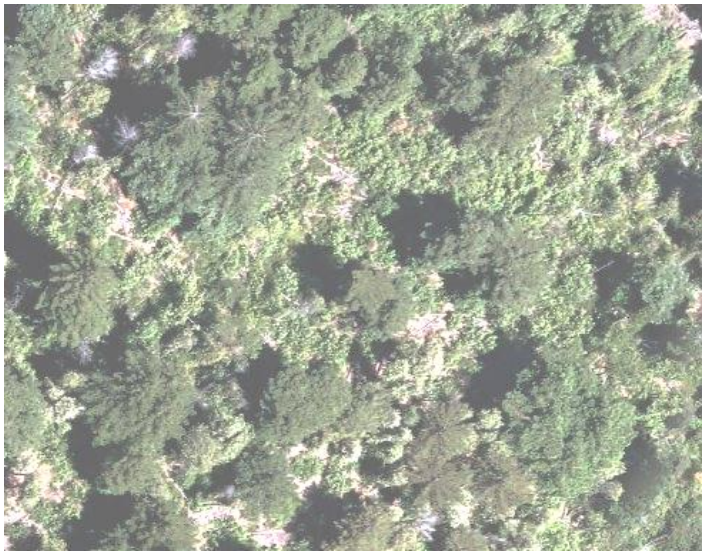

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Table of Contents

Introduction

In 2015, Marin Municipal Water District (MMWD) contracted Aerial Information Systems, Inc. (AIS) to conduct the photo interpretation of sudden oak death (SOD) affected vegetation stands for the Mt. Tamalpais Watershed Forest and Woodlands Project. The resulting database is an update of impacts on vegetation from Sudden Oak Death from 2009 to 2014. There are 2 ArcGIS feature classes within the 2014 database: Vegetation and LargestGaps. The Vegetation feature class is an update of the 2009 vegetation database, containing 4 new fields created to help quantify the effects of SOD within polygons. The LargestGaps feature class is new for this update and reflects the largest single continuous gap within a polygon that is a result of SOD (see Additions to the 2014 Vegetation Map section). (See Figure 1 below)

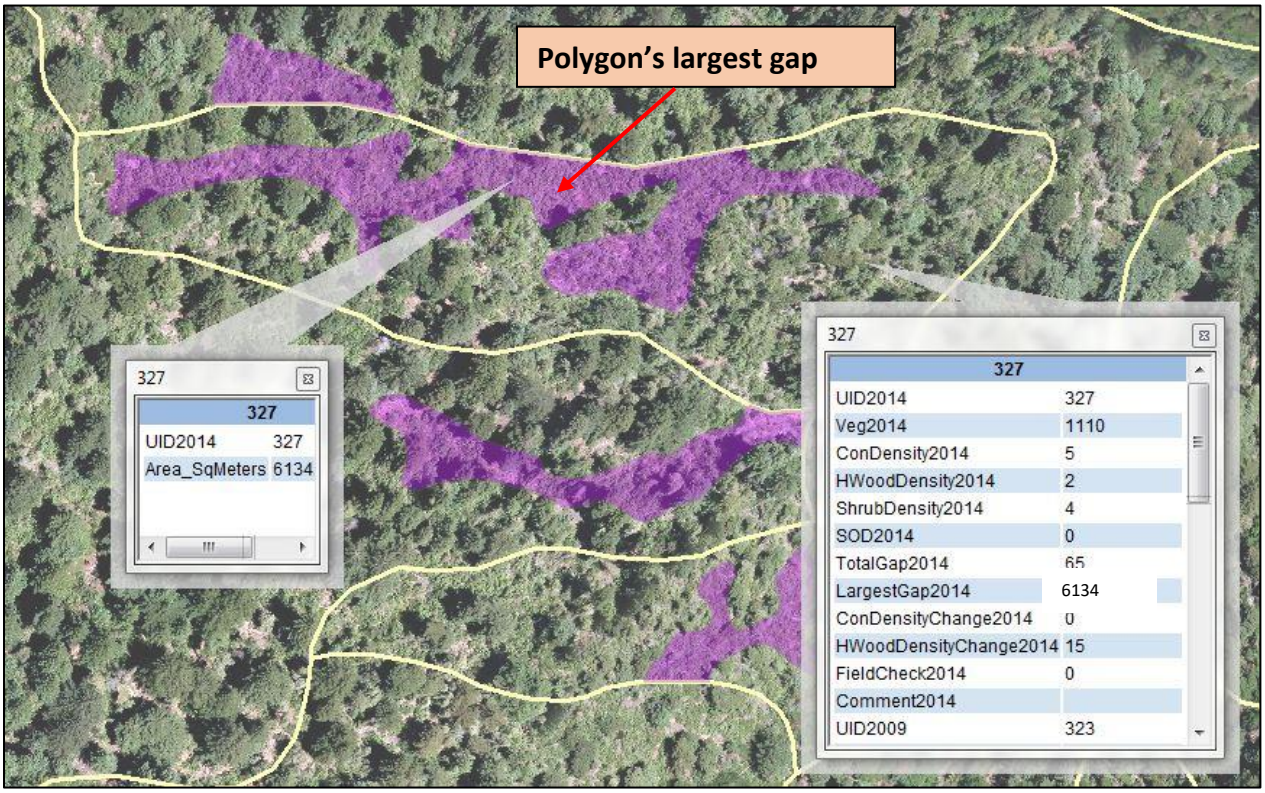

Figure 1: New feature class (LargestGaps) showing total area of the largest canopy gap in each polygon affected by sudden oak death. The largest gap polygon for polygon 327 (UID2014 327) is shaded in purple. The table on the right references the "parent" vegetation polygon depicting in this example all of the 2014 attributes for that particular polygon. 2009 & 2004 attributes are not displayed in this figure for simplicity. The original mapped UID2009 is displayed at the bottom of the table to the right. The UID2009 field enables the user to reference the same polygon on the 2009 vegetation map.

Overview

The purpose of the database is to inventory the severity of SOD in the Mt. Tamalpais Watershed reflecting 2014 conditions and measure the SOD related changes over a 5-year period from 2009 to 2014. This project originated in 2004, when a vegetation map was created for the Mt. Tamalpais Watershed including the Nicasio and Soulajule Reservoirs, using the MMWD Preliminary Mapping Classification. A dead vegetation modifier (named SOD2004) was used to identify areas impacted by SOD. For the 2009 and 2014 updates, the original study area was reduced by excluding the Nicasio and Soulajule Reservoirs. In addition, only a subset of polygons were evaluated for the 2009 and 2014 databases. The subset only consisted of vegetation polygons that had potential to be affected by SOD (approximately 50 different vegetation types that are noted in Appendix B with an asterisk).

In addition to the attributes previously mapped in 2009, there were 4 new attributes created for the 2014 data update. These new attributes (TotalGap2014, LargestGap2014, ConDensityChange2014, and HWoodDensityChange2014) were related to the effects that sudden oak death had on impacted stands of vegetation. See the Additions to the 2014 Vegetation Map section of the report for a description of these attributes.

Once SOD has infected a tree, the eventual demise of the tree can take a number of years, depending on the species. After the tree has completely died and fallen to the ground, an opening in the canopy is created. These openings are referred to as “gaps” and can be either barren or vegetated on the 2014 imagery, depending on the original cover type, environmental setting and/or level of SOD severity.

In the study area, sudden oak death was primarily observed directly affecting 2 species: tanoak and coast live oak. To a lesser extent, it affected other species as well (e.g. black oak and giant chinquapin) but the majority of the die-off and resultant gaps were noted in stands historically containing either tanoak or coast live oak.

When SOD was detected in stands that affected tanoak, the tanoak usually took more than 5 years to totally die off and create a gap in the canopy. Since 2004, the number of tanoak stands has greatly decreased in the watershed (see Appendix E for SOD Tables). In 2014, there were still tanoak individuals present, however, stands mapped to the tanoak alliance or a vegetation type co-dominating with tanoak were rare. In general, the gaps created by dead tanoaks were replaced with another type of vegetation relatively quickly. Occasionally, California bay tree saplings or shrubs such as blue blossom were noted in these gaps, but the majority of the gaps in tanoak – mixed conifer forest settings were repopulated with California huckleberry (*Vaccinium ovatum)*. Once a gap was created after SOD devastation, a notable change in density (conifer, hardwood or shrubs) may take place. When a change in density for either hardwood or conifer occurred, and it was at least 2.5%, then a change in density was attributed in +/- 5% increments. When a change in density in shrub cover was observed in the stand, the shrub cover class category was updated, only if that change corresponded to a different cover class category.

When SOD was noted in stands that affected coast live oak, the diseased trees felled relatively quickly, usually creating a gap within a 5-year span. In many examples, living coast live oaks were seen on the 2009 imagery that were completely downed by 2014, resulting in a gap in the stand that contained only the larger branches of the downed tree. Standing dead coast live oak trees were rarely seen on the 2014 imagery, but when they were encountered, they were inventoried as part of the dead vegetation modifier (SOD2014) instead of the gap. The gaps that were created from dead coast live oak were frequently sparsely vegetated, with little to no new shrubs or trees regenerating in the location. This resulted in a loss of hardwood within the polygon. (See Figure 2 below)

Figure 2: Complete cycle from 2009 (image on left) to 2014 depicting unaffected coast live oak to a fully downed tree in 2014. In this example the SOD 2014, 2014 Hardwood Change and Total Gap fields are all assessed since all events occurred after the 2009 imagery was created.

Mapping Conventions and Methodologies

Update Mapping

Update mapping is the process of revising the spatial and attribute data of an existing dataset using current sources of information for change detection. When the attributes are analyzed in a geographic information system (GIS), areas of change are noted. Ideally, the project classification, mapping criteria, and data capture method of the update should be the same as the previous data compilation effort in order to make accurate comparisons. For the 2014 update, the project classification remained the same as the 2009 mapping effort. The mapping criteria remained the same (e.g. review vegetation code, densities and SOD modifier) except for the analysis of the 4 new variables, noted in the Additions to the 2014 Vegetation Map section. The data capture method was the same with the exception of adding a new ArcGIS feature class (named LargestGaps) to delineate the largest gaps in appropriate polygons. Note that all attributes had the potential to be modified, not just the 4 newly created ones for this project.

The 2014 attributes were the focus of this vegetation map, but on some occasions a need to reclassify codes in 2009 or 2004 were necessary. This need to retroactively change codes prior to 2014 was rare and was usually a result of the 2014 imagery yielding better clarity of an area.

Data Inventory, Organization of Project Materials and Uploading of Digital Files

Primary data Sources

Several data sources were used during the mapping process. The primary data sources are listed below.

- ***2014 digital imagery:*** This 6-inch resolution, natural color imagery, dated 2014 and provided by MMWD, served as the base for the 2014 mapping update. The imagery was uploaded to AIS servers.

- ***2009 SOD Vegetation database:*** The 2009 Vegetation database was used as the base for the 2014 SOD Vegetation database update.

Ancillary Data Sources

There were several sources of ancillary data used to help facilitate the 2014 vegetation mapping. They are listed below:

- Topology maps
- Contour lines
- Field recon points from the 2004 Vegetation Mapping project
- 2004 digital imagery
- 2009 digital imagery
- Google Earth imagery

Preliminary Digital Imagery Signature Identification

Prior to the mapping process, the photo interpreters reviewed the project area with the 2014 digital imagery in order to identify any problematic signatures and develop any questions for the MMWD Ecologist.

Photo Interpretation

After the base imagery for the project was uploaded onto the AIS servers, the photo interpretation could begin. Following many of the same mapping rules and criteria established for the 2009 database, the photo interpreter used heads-up digitizing techniques and custom ArcGIS tools that AIS developed to update the existing database.

The 2009 database was used as the starting point for the 2014 SOD vegetation update. A selection on the Veg2009 codes was created that included all mapping types that had potential to be affected by sudden oak death, which was approximately 50 types (see Appendix B for designation of which types were included in the selection). This resulted in roughly 2200 polygons (approximately 13, 000 acres) to be reviewed for the 2014 SOD vegetation update.

When possible, the photo interpreter worked in regions that contained similar vegetation types. Within these regions, the photo interpreter would visit the polygons from the SOD selection set and evaluate them in the context of SOD modifications to the floristic, structural and health of the vegetation. By focusing on smaller, similar areas within the study area, the photo interpreter became more familiar with the region and local trends in the vegetation.

Registration between the 2009 imagery and the 2014 imagery was evaluated to ensure the accuracy of the database. The 2014 base imagery was then compared to the 2009 vegetation database for any changes. If any changes were detected, then the attributes were updated to reflect the change. Occasionally, this resulted in a polygon being split based on differing levels of SOD devastation within the stand. The 2014 imagery was then compared to the 2004 imagery in order to analyze the gaps within each polygon. The 2004 imagery was used as the starting point for measuring the gaps.

As mapping progressed, the spatial registration between the 2009 and 2014 sets of imagery was found to be inconsistent in some areas. There were also splicing errors found in a few locations on the 2014 imagery. In addition, because only a selected set of polygons were reviewed for SOD in this update project, and the ID number assigned each polygon in 2009 (UID2009) was retained, the original linework from 2009 was unaltered. For this reason, within the Vegetation feature class, the spatial base imagery for the vegetation polygons remained to be the 2009 image dataset. The 2014 attributes for each vegetation polygon were coded based on the 2014 imagery since it was the most current imagery. Since 2014 imagery was solely used to delineate the largest gap polygons within the LargestGaps feature class, the spatial base imagery for the LargestGaps feature class was therefore the 2014 image dataset.

In other words, unless the polygon boundaries within the Vegetation feature class had changed due to a change in attributes (e.g. vegetation change, change in density, etc.), the boundaries were kept as they were mapped to the 2009 imagery but the polygon attributes were updated using the 2014 imagery. However, for the LargestGaps feature class, the largest gap delineations were based on the 2014 imagery since it was the most current imagery available. ***Note** that if a vegetation polygon was split due to 2014 conditions, it created multiple vegetation polygons in the Vegetation feature class that contained the same UID2009 values, but different UID2014 values. This was not common within the study area.

Base Imagery Used for 2014 Mapping Update

ArcGIS Feature Class	**Imagery Used for Spatial Base (location of polygons)**	**Imagery Used for Attribute Base (attribute coding)**
Vegetation	2009	2014
LargestGaps	2014	2014

Additions to the 2014 Vegetation Map

New ArcGIS Feature Class

As a result of mapping the new attribute called LargestGap2014 (see New Attributes section below), a new ArcGIS feature class was created in order to show the location of the largest gaps within polygons that contained one. The largest gap was mapped when a polygon had been affected by SOD at some time between 2004 and 2014, which resulted in a measurable continuous gap within the polygon. The best way to inventory the size of the largest gap was to map it within the polygon in the Vegetation feature class. The largest gap polygons were then extracted into a separate ArcGIS feature class, named LargestGaps, within the 2014 database. There were only 2 attributes that were coded for the LargestGaps feature class: UID2014 and AreaSqMeters. The UID2014 attribute correlated with the UID2014 in the Vegetation feature class since they were both located within the same vegetation polygon. The area of the largest gap was in the AreaSqMeters attribute within the LargestGaps feature class and correlated with the LargestGap2014 attribute in the Vegetation feature class.

Correlating Attributes Within Vegetation and LargestGaps Feature Classes in the 2014 Database

ArcGIS Feature Class	**Correlating Attribute Names**	**Correlating Attribute Names**
Vegetation	UID2014	LargestGaps
LargestGaps	UID2014	AreaSqMeters

New Attributes

Four new attributes for the Vegetation feature class were created for the 2014 update (TotalGap2014, LargestGap2014, ConDensityChange2014, and HWoodDensityChange2014). Two were related to measuring the gaps within a polygon from 2004 to 2014, and the other 2 were the density changes of hardwood and/or conifer from 2009 to 2014, usually due to SOD.

Gap Analysis

Since the vegetation map was initially created in 2004, the 2004 data was used as the benchmark for starting conditions related to the gap measurements. Within the Vegetation feature class, the total gap percentage (TotalGap2014 attribute) and the largest gap (LargestGap2014 attribute) were measured from 2004 to 2014. TheTotalGap2014 attribute was a collective measurement of all the gaps within a polygon and was assigned a percentage in 5% increments. The LargestGap2014 attribute was the area in square meters of the largest continuous gap within a polygon. Several vegetation polygons that were evaluated had multiple gaps within them, but did not have a LargestGap2014 attribute defined because the existing gaps were extremely small and discontinuous across the stand. The largest gap polygons were located within a separate feature class, named LargestGaps, within the 2014 database.

Density Changes

Density changes in conifer and hardwood were only evaluated in the polygons that were selected for SOD impact between 2009 and 2014. The density changes were measured in positive or negative 5% increments, using 2.5% as the floor for measurable change (rounding up to 5%). In most examples, the conifer density changes were due to increasing crown size, but in some cases, it was due to saplings regenerating in a gap. The hardwood density changes that resulted in an increase were generally due to the young California bay saplings that regenerated in the gaps left from dead tanoak trees. Decreases in hardwood density were usually found in areas of coast live oak death since there was little to no regeneration of hardwoods in this setting. Note that increases or decreases in shrub cover were indicated in a cover class change from 2009 to 2014 only where the change was significant enough to change cover classes.

See Figure 3 below visually depicting the 4 new attributes:

- Total Gap Percentage (TotalGap2014) – Example below: 70% of the polygon is a gap
- Largest Gap in the polygon (LargestGap2014) – Example below: 2068 square meters
- Conifer Density Change – Example below: 5% increase from 2009
- Hardwood Density Change – Example below: 10% increase from 2009

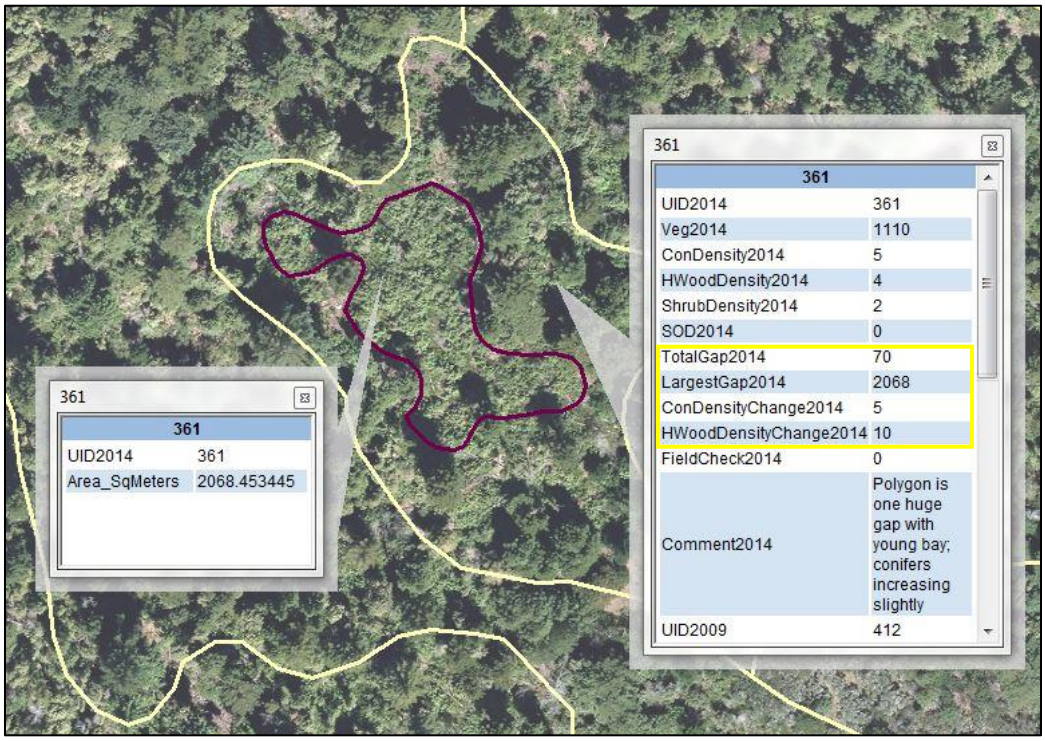

Figure 3: Four new attributes in the Vegetation feature class (highlighted in yellow), as depicted in the table to the right. Largest gap of the parent vegetation polygon is outlined in purple (also a new feature class named LargestGaps) to the left with its corresponding area. Other attributes in the vegetation polygon were also reviewed for change. Polygons in both feature class have the same UID2014 and area of largest gap. Not depicted in this example is a change in shrub cover from less than 2% (Category 0) in 2009 to 40-60% (Category 2) in 2014.

Attributes for the 2014 Update

The attributes coded for the 2014 Vegetation feature class are listed below with a brief description (see Appendix C for attribute values).

UID2014: Unique ID number for each polygon mapped in 2014. This number also corresponds to the polygon ID number (UID2014) in the LargestGaps feature class.

Veg2014: The updated 4-digit numeric code that corresponds to the floristic type from the MMWD Vegetation Mapping Classification (see Appendix B for the Mapping Classification).

ConDensity2014: The updated conifer cover class, assigned by using a range of values.

HWoodDensity2014: The updated hardwood cover class, assigned by using a range of values.

ShrubDensity2014: The updated shrub cover class, assigned by using a range of values.

SOD2014: The updated SOD Severity (also referred to as Dead Vegetation) Modifier, assigned by a range of values.

TotalGap2014: The collective area of any gaps within the polygon since 2004, mapped in 5% increments. The value represents a percent of the total polygon covered in gaps.

LargestGap2014: The area of the largest continuous gap created since 2004. The LargestGap2014 in the Vegetation feature class corresponds to the AreaSqMeters attribute in the LargestGaps feature class.

ConDensityChange2014: Mapped in +/-5% increments, the change of conifer density in a polygon since 2009, usually as a result of SOD. In some instances the change was not a result of SOD, but was noted as such in the Comments2014 attribute.

HWoodDensityChange2014: Mapped in +/-5% increments, the change of hardwood density in a polygon since 2009, usually as a result of SOD. In some instances the change was not a result of SOD, but was noted as such in the Comments2014 attribute.

FieldCheck2014: Attribute used to flag polygons that were sent as questions or answered by MMWD staff.

Comment2014: Answers to field questions along with and any other pertinent information associated with the mapped polygon was put in this attribute.

The attributes coded for the 2014 LargestGaps feature class are listed below with a brief description (see Appendix C for attribute values).

UID2014: Unique ID number for each polygon mapped in 2014. This number also corresponds to the polygon ID number (UID2014) in the Vegetation feature class.

AreaSqMeters: The LargestGap2014 in the Vegetation feature class corresponds to the AreaSqMeters attribute in the LargestGaps feature class.

Field Checking Effort

During the photo interpretation process, questions that arose were noted by flagging the polygon, which were then answered by the MMWD Ecologist. These answers were implemented into the 2014 database and extrapolated as necessary throughout the study area.

Quality Control

Once the photo interpretation was completed and answers to the field questions were incorporated in the database, a comprehensive quality control (QC) was performed by the senior photo interpreter. The QC steps included a visual check on signature and attribute correlation as well as automated programs to check the validity of coding and linework.

Final Processing and Documentation

Automated processes were performed on the database to create a seamless coverage with no GIS errors. Upon completion of the steps above, AIS provided MMWD with a Photo Interpretation Summary Report and the final data, in digital format, with supporting metadata.

APPENDIX A

AREA REPORT

VEG2014 Type	Frequency	Area (acres)
1100	6	6.75
1101	103	583.27
1102	19	168.48
1103	26	90.89
1104	60	584.61
1110	149	785.47
1111	96	450.52
1112	6	7.45
1113	260	517.67
1114	127	670.79
1115	68	226.76
1116	12	63.03
1117	60	733.00
1160	19	27.44
1170	35	64.33
1171	28	70.88
1180	44	48.60
1201	7	14.60
1210	8	4.62
1211	2	13.68
1212	91	1482.53
1213	2	1.71
1214	76	712.72
1215	63	121.28
1216	97	1168.78
1217	33	368.20
1220	18	33.29
1221	52	236.29
1222	208	3072.45
1223	36	109.11
1224	1	47.10
1225	2	2.95
1226	26	26.30
1227	53	124.20

VEG2014 Type	Frequency	Area (acres)
1230	8	9.36
1231	11	13.35
1232	6	7.53
1240	6	14.64
1241	77	289.84
1242	24	33.76
1310	10	4.76
1410	4	5.65
2110	46	100.37
2111	124	205.03
2112	2	1.99
2113	8	17.08
2210	5	6.15
2220	16	11.90
2231	2	9.98
2321	2	4.85
3000	1	0.30
3100	2	0.56
3110	8	4.39
3112	65	49.91
3114	148	116.69
3115	150	174.68
3120	83	69.87
3121	324	516.68
3122	45	91.25
3130	37	87.03
3140	2	0.19
3150	58	91.18
3160	32	24.53
3161	352	752.70
3170	3	2.56
3180	76	83.60
3190	412	1056.62
3210	41	25.71
3220	6	4.59
3221	18	11.03
3222	87	52.84

VEG2014 Type	Frequency	Area (acres)
3223	45	30.93
3310	3	2.04
3311	11	7.16
3410	5	1.98
4101	3	1.33
4110	5	2.57
4120	1	0.24
4210	12	3.15
4211	16	12.71
4310	4	1.16
4311	290	1042.33
4312	30	86.94
4313	44	39.99
4400	1	0.39
4500	6	22.74
4510	3	0.63
4520	1	0.77
4610	151	126.96
4620	8	1.82
9000	1	14.64
9100	48	65.32
9302	2	4.73
9400	31	14.92
9401	95	30.09
9420	78	14.68
9810	8	847.70
9820	2	0.13
9999	20	12.39

APPENDIX B

Marin Watershed Mapping Classification

Revised for SOD Update – October 2011

**= Types reviewed for the 2014 SOD Update*

CLASS

Group or Formation Level Categories

Alliances

Mapping units or Potential Associations yet to be defined

1000 – 2000 – FORESTS & WOODLANDS

*1100 – Temperate Broadleaf Sclerophyll Evergreen Forests & Woodlands (Mixed Hardwoods)

1101 – Lower Elevation Mixed Broadleaf Mapping Unit (Trending Xeric) – Coast Live Oak, Madrone or Black Oak dominant* *(At least two species co-dominate, may include Madrone – Coast Live Oak, Black Oak – Coast Live Oak, or Black Oak – Madrone.)***

1102 – Tanoak – California Bay – Canyon Oak Mixed Forest* *(Either Tanoak or California Bay dominate but the other either co-dominates or is present. Canyon Oak may or may not be present but generally does not co-dominate.)***

1103 – California Bay – Alder – Big Leaf Maple – Willow spp. Riparian Forest (**California Bay is always present in association with any or all three riparian species.)***

1104 – Madrone – California Bay – Tanoak* *(Madrone co-dominates with either Tanoak or California Bay including Madrone – Tanoak, Madrone – California Bay, and California Bay – Black Oak – Madrone.)***

**1110 – California Bay Alliance*

**1111 – California Bay (pure)*

**1112 – California Bay – Buckeye*

**1113 – California Bay – Interior Live Oak*

**1114 – California Bay – Canyon Oak*

**1115 – California Bay – Coast Live Oak*

**1116 – California Bay – Tanoak*

**1117 – California Bay – Madrone*

**1140 – Tanoak Alliance*

**1160 – Madrone Alliance*

1170 – Canyon Oak Alliance* *(Includes Canyon Live Oak with lower cover of Tanoak.)***

**1171 – Canyon Oak – Interior Live Oak*

1180 – Giant Chinquapin Alliance* *(Includes a possibility of 3 associations that include Eastwood Manzanita, and stands are sometimes shrub-like in nature.)***

*1200 – Temperate Needleleaf Evergreen Forests & Woodlands

**1201 – Planted Stands of Pine (Monterey Pine – Bishop Pine – Monterey Cypress and other spp.*

**1210 – Redwood Alliance*

1211 – Redwood / Tanoak* *(Includes a possibility of at least 2 associations.)***

**1212 – Redwood – Douglas-fir – (Mixed Hardwoods)*
**1213 – Redwood / Chinquapin*
**1214 – Redwood / California Bay*
1215 – Redwood (pure)* *(often young dense stands)***
1216 – Redwood - Upland Mixed Hardwoods (**Generally California bay, Tanoak, occur as co-dominant or subordinate species in upland settings.)***
1217 – Redwood – Riparian* *(Redwoods in riparian settings with maple, California bay, Tanoak, and/or White alder in the secondary canopy.)***
1218 – Redwood – Madrone* *(Surveys suggest this type with Vaccinium ovatum in the understory)***
**1220 – Douglas-fir Alliance*
1221 – Douglas-fir - Mixed Hardwoods in upland drier settings (Coast Live Oak, Madrone)* *(Generally in smaller stands often adjacent to grassland or shrublands.)***
1222 – Douglas-fir Mixed Hardwoods in upland forest settings (California Bay, Canyon Oak, Tanoak – Madrone)* *(Canyon Oak often occurring in larger stands adjacent to other conifer forests.)***
1223 – Douglas-fir – California Bay Mapping Unit* *(May include Coast Live Oak as an associate.)***
**1224 – Douglas-fir – Tanoak*
1225 – Douglas-fir – Riparian* *(Douglas-fir in riparian settings with White Alder, Blackberry, etc., in understory.)***
1226 – Douglas-fir (pure)* *(Little understory development other than Douglas-fir regenerating)***
**1227 – Douglas-fir – California Bay / Interior Live Oak*
1230 – Bishop Pine Alliance
1231 – Bishop Pine / Eastwood Manzanita
1232 – Bishop Pine (pure)
1240 – Sargent Cypress Alliance
1241 – Sargent Cypress / Mt. Tamalpais Manzanita
1242 – Sargent Cypress (pure)
1243 – Sargent Cypress – Riparian ***(May be very rare.)***

1300 – Temporarily Flooded Cold Season Deciduous Forests & Woodlands

1310 – Mixed Willow Mapping Unit (Arroyo Willow, Red Willow, and Yellow Willow Alliances)
1320 – White Alder Alliance
1321 – White Alder – California Bay
1330 – Red Alder Alliance

*1400 – Cold Season Deciduous Forests

**1410 – Black Oak Alliance*

*2000 – WOODLANDS

*2100 – Xeric Sclerophyll Evergreen Forests & Woodlands

**2110 – Coast Live Oak Alliance*
**2111 – Coast Live Oak / (Grass-Poison Oak)*
**2112 – Coast Live Oak – Riparian*

*2113 – Coast Live Oak – Douglas-fir **(A small component of conifer cover (< or = 5%), as compared to 1221)**

*2200 – Cold Season Deciduous Woodlands

*2210 – Oregon Oak Alliance (small stands) **(Includes Oregon Oak mixed with lower to equal Coast Live Oak or California bay cover)**

*2220 – California Buckeye Alliance **(Includes California Buckeye mixed with lower Coast Live Oak) [mapped based on plot data and some local extrapolation]**

*2230 – Valley Oak Alliance

*2231 – Valley Oak Riparian Mapping Unit **(California Bay and/or Big Leaf Maple- Alder are a co-dominant in a riparian setting)**

*2300 – Temporarily Flooded Cold Season Deciduous Woodlands

*2320 – Big-leaf Maple Alliance

*2321 – Big-Leaf Maple – California Bay Mapping Unit **(May be co-dominant or one slightly higher in cover than the other.)**

3000 – SHRUBLANDS

3100 – Temperate Broadleaf Sclerophyll Evergreen Shrublands

3110 – Chamise Alliance

3112 - Chamise - Serpentine Chaparral **(Relatively pure chamise on ultramafic soils)**

3114 – Chamise **(Stands with a co-dominance of chamise with other shrub species such as Sticky Monkey-flower or Wedgeleaf Ceanothus)**

3115 – Chamise (pure)

3120 – Mt. Tamalpais Manzanita Alliance **(Includes possibly 3 associations with Eastwood Manzanita, Chamise, or Jepson's Ceanothus as associates.)**

3121 - Mt. Tamalpais Manzanita - Chamise - (Garraya - Leather Oak – Jepson ceanothus) – Serpentine Chaparral)

3122 – Mt. Tamalpais Manzanita - \ with Sparse Douglas-fir emergent (5 - 25%)

3130 – Sensitive Manzanita Alliance **(Small stands that may include Eastwood Manzanita or Huckleberry.)**

3132 – Jepson's Ceanothus (stand noted at Nicasio Reservoir)

3140 – Silver Leaf Manzanita Alliance **(Small stands that may include Eastwood Manzanita and Chamise.)**

3150 – Eastwood Manzanita Alliance **(May have up to 10-15% Douglas-fir emergent)**

3160 – Interior Live Oak Alliance

3161 – Interior Live Oak- Eastwood Manzanita **(QUWI and ARGL co-dominate)**

3170 – Blue Blossom Alliance **(Small stands, and may include at least 2 associations with Coyote Brush – Poison Oak and with Shrub Interior Live Oak.)**

3180 – Leather Oak – Chamise – Mt. Tamalpais Manzanita Serpentine Chaparral

3190 –Chamise – Eastwood Manzanita

3200– Temperate Microphyllous Evergreen Shrubland

3210 – (French) Broom Alliance ***(May include low cover of Coyote Brush.)***
3220 – Coyote Brush Alliance
3221 – Coyote Brush – California Sagebrush – Sticky Monkey Flower
3222 – Coyote Brush / Annual or Perennial Grasslands (open stands)
3223 – Coyote Brush – Mixed Shrub / Grass ***(May include Poison Oak or California Blackberry with mixture of grass species.)***

3300 – Temperate Xeric Mixed Drought-Deciduous Evergreen Shrubland

3310 - California Sagebrush Alliance
3311 – California Sagebrush – Sticky Monkey Flower

3400 – Temperate Broadleaf Cold Season Deciduous Shrubland

*3410 – Poison Oak Alliance (****Small stands found in Coyote Brush patches)***
3420 – Riparian Deciduous Shrubland ***(Includes Western Azalea.)***

4000 – HERBACEOUS

4100 – Saturated Temperate Perennial Graminoids

4101 – Undifferentiated Marsh (cattail, bulrush, other scirpus spp.)
4110 – Cattail Alliance
4120 – Bulrush Alliance

4200 – Seasonally or Temporarily Flooded Graminoids

4210 –Sedge – Rush – Wet Graminoids Meadow (Including Juncus, Carex, and Hordeum brachyantherum – Meadow barley)
4211- Temporarily flooded or saturated Meadow Edge

4300 – Tall Temperate Annual Graminoids

4310 – California Annual Grasslands Alliance (Native Component Variable)
4311 – Grasslands on well-developed soils ***(generally dense bio-mass)***
4312 – Grasslands on poorly developed soils ***(generally sparse bio-mass)***
4313 – Grasslands with a fern or sub-shrub component (either Thermopsis or fern)

4400 – Tall Temperate Perennial Herbaceous
4410 – Harding Grass Alliance
4420 – Teasal Alliance (Dipsacus sativa)
4430 – Reed Canary Grass Alliance (Festuca arundinacea)

4500 – Native Temperate Perennial Grasslands

4510 – California or Idaho Fescue Grasses ***(Small patches in grassland settings.)***
4520 – Purple Needlegrass ***(Small patches with annual grasses and sometimes other native grasses such as California Melic)***

4600 – Serpentine Grassland

4610 – Upland Serpentine Grassland ***(May include perennial and annual species at varying cover seasonally and annually, such as Purple Needlegrass, Torrey's Melic, Dwarf Plantain, Small Fescue, Sticky Western Rosinweed)***

4620 – Wetland Serpentine Grassland ***(May include perennial and annual species at varying cover seasonally and annually, such as Meadow barley, Rosinweed, Goldfields, etc.)***

9000 – LAND USE / UNVEGETATED

9800 – WATER

9100 – Urban Developed – Built Up

9302 – Quarry

9400 – Sparsely Vegetated or Unvegetated Areas

9401 - Serpentine Balds ***(Including rare species such as Tamalpais Jewelflower)***

9410 – Landslides

9420 – Cliffs – Rock Outcrops

9810 – Reservoirs

9820 – Small Asian Elephant Ponds (it just won't change, will it) – never in a thousand years

9999 – Field questions

APPENDIX C

MMWD SOD Vegetation Mapping Attribute Values for 2014 Update

Vegetation Feature Class Attribute Values

UID2014: Unique ID number for polygons in 2014 database

Veg2014: 4-digit code that corresponds with floristic type from the MMWD Mapping Classification in the 2014 database (see Appendix B)

ConDensity2014, HWoodDensity2014, ShrubDensity2014: Densities for conifer, hardwood and shrubs in the 2014 database

Density 2014 Range	
Code Value	Range
0	<2%
1	>60%
2	40-60%
3	25-40%
4	10-25%
5	2-10%

SOD2014: Updated Sudden Oak Death (dead vegetation) Severity Code in the 2014 database
Note: Evaluation of SOD is done on the total tree cover of the affected polygon.

SOD Modifier 2014 Values	
Code Value	SOD Severity
0	No mortality
1	Low: 1-5% of polygon has canopy mortality
2	Moderate: 5-10% of polygon has canopy mortality
3	Severe: >10 of polygon has canopy mortality
4	Trace: <1% of polygon has canopy mortality

TotalGap2014: Percentage of collective gap within a polygon in the 2014 database, using 5% increments

Total Gap 2014 Values	
Code Value	Increments (in 5%)
0	0 - 2.5%
5	>2.5% - 7.5%
10	>7.5% - 12.5%
15	>12.5% - 17.5%
20	>17.5%- 22.5%
25	>22.5% - 27.5%
30	>27.5% - 32.5%
35	>32.5% - 37.5%
40	>37.5% - 42.5%
45	>42.5% - 47.5%
50	>47.5% - 52.5%
55	>52.5% - 57.5%
60	>57.5% - 62.5%
65	>62.5% - 67.5%
70	>67.5% - 72.5%
75	>72.5% - 77.5%
80	>77.5% - 82.5%
85	>82.5% - 87.5%
90	>87.5% - 92.5%
95	>92.5% - 97.5%
100	>97.5%- 100%

LargestGap2014: Area of largest gap within a polygon in the 2014 database, in square meters

FieldCheck2014: Indicates a polygon that was flagged for a field question or visited/ answered by MMWD staff in the 2014 database

Field Check 2014 Values	
Code Values	Type of Field Check
0	No field question
1	Flagged for field questions
2	Field question answered

Comment2014: Within the 2014 database, answers to field questions along with and any other pertinent information associated with the mapped polygon was contained in this attribute.

ConDensityChange2014, HWoodDensityChange2014: Changes in density in the 2014 database, in 5% increments. Note that a minus sign (–) indicates a decrease in density. 2.5% was used as lowest number to round up to 5%.

Density Change 2014 Values	
Code Value	Increments (in 5%)
0	0 - 2.5%
+/- 5	+/- >2.5% - 7.5%
+/- 10	+/- >7.5% - 12.5%
+/- 15	+/- >12.5% - 17.5%
+/- 20	+/- >17.5%- 22.5%
+/- 25	+/- >22.5% - 27.5%
+/- 30	+/- >27.5% - 32.5%
+/- 35	+/- >32.5% - 37.5%
+/- 40	+/- >37.5% - 42.5%
+/- 45	+/- >42.5% - 47.5%
+/- 50	+/- >47.5% - 52.5%
+/- 55	+/- >52.5% - 57.5%
+/- 60	+/- >57.5% - 62.5%
+/- 65	+/- >62.5% - 67.5%
+/- 70	+/- >67.5% - 72.5%
+/- 75	+/- >72.5% - 77.5%
+/- 80	+/- >77.5% - 82.5%
+/- 85	+/- >82.5% - 87.5%
+/- 90	+/- >87.5% - 92.5%
+/- 95	+/- >92.5% - 97.5%
+/- 100	+/- >97.5%- 100%

2009 attributes (with updates to the names in the 2014 database):

2014 Database Name	2009 Database Name
UID2009	AIS_ID
Veg2009	Veg_09
ConDensity2009	ConDensity_09
HWoodDensity2009	HWoodDensity_09
ShrubDensity2009	ShrubDensity_09
*Broom2009	Broom_09
SOD2009	SOD_09
FieldCheck2009	FieldCheck_09
Comment2009	Comment_09
Veg2004	Veg_04
ConDensity2004	ConDensity_04
HWoodDensity2004	HWoodDensity_04
ShrubDensity2004	ShrubDensity_04
*Broom 2004	Broom
SOD2004	SOD_04
Comment2004	Note_04
FieldCheck2004	Field_04

**Not evaluated in 2014 effort*

LargestGaps Feature Class Attribute Values

UID2014: Unique ID number

AreaSqMeters: Area of largest gap polygon in square meters

APPENDIX D

SUDDEN OAK DEATH VS. GAP GUIDELINES

Sudden Oak Death (dead vegetation) Measurements

Death in vegetation (SOD2014 attribute) is only measuring die-off severity between 2009 and 2014.

If dead vegetation is visible in 2009, then it is not counted in the SOD2014 field since it occurred before 2009, even if it is still visible in 2014. This enables the user to evaluate the actual die-off that has occurred since the 2009 update.

If a complete death cycle has occurred between 2009 and 2014 (e.g. it is alive on 2009 imagery, but dead or gone on 2014 imagery), the polygon **DOES** get counted in the 2014 SOD variable (common in coast live oak settings).

Standing dead trees count as a component to the dead vegetation modifier, not to the gaps.

For the most part, SOD in coast live oak stands observed in 2014 is death that has occurred since 2009 since die-off normally occurs during a relatively short period of time. This includes the gaps that have been created from coast live oak trees that have died and felled since 2009 as well as any early stages of sudden oak death occurring in the canopy since 2009. When a coast live oak is dead and down, it is coded as part of the gap AND the dead vegetation modifier even if the downed remains are visible on the imagery.

When a death severity is noted in the SOD2014 field, with little or no hardwoods regenerating in the canopy openings, there will be generally be a hardwood density loss noted in the hardwood density 2014 field. These situations more often occur in coast live oak types. When a death severity is noted in the SOD2014 field with hardwood regeneration since 2009, then an increase in cover will be noted in the hardwood density 2014 field. If the canopy gap is regenerating primarily by shrub species, then the shrub density 2014 cover class value will be increased if the change is significant enough to change cover classes. Both of these situations more often occur in tanoak types.

Conifer death is not counted when assessing the Updated SOD Severity code.

Gap Measurements

Gaps are measured from 2004 until 2014. An opening in canopy resulting from SOD (as long as it occurred prior to the 2014 imagery) is considered part of the gap.

Gaps are openings created from dead trees that have fallen due to SOD. The gaps include any new growth of vegetation regardless of stature.

Conifer death does not count towards the gap modifiers.

Standing dead trees do not count as a gap. Standing dead is more frequently noted in tanoak and mixed tanoak forests. Diseased coast live oaks tend to take less time to fall and will more often create gaps soon after the trees die.

If the collective gap in a polygon is small (<2.5%), a value of 0% is defined for Total Gap Percentage. Minor canopy openings such as these that are due to SOD is noted in the comments field.

The LargestGap2014 attribute measures the presence of a continuous, uninterrupted gap in an existing polygon. Small gaps that normally occur in a forest canopy are not measured as part of this attribute.

For the most part, gaps are not mapped under tree canopies or in shadows unless a clearly visible gap extends beyond the shadowed area.

APPENDIX E

SUDDEN OAK DEATH TABLES

Table 1

Decrease in Tanoak and Mixed Tanoak Forests by Type (area in acres)

VEG2014 Type	Area 2014	Area 2009	Area 2004
1102	168.48	226.67	617.07
1104	584.61	580.12	1191.92
1116	63.03	284.57	917.96
1140	0.00	0.00	53.46
1211	13.68	14.05	152.44
1212	1482.53	1520.12	1519.76
1216	1168.78	1272.77	1536.62
1217	368.20	368.20	368.20
1222	3072.45	3074.97	3081.79
1224	47.10	47.10	47.10
Total Area:	**6968.87**	**7388.57**	**9486.31**

Table 2

Decrease in Hardwood Cover in Coast Live Oak Woodland Types Since 2009

VEG2014 Type	HW Change -25%	HW Change -20%	HW Change -15%	HW Change -10%	HW Change -5%	HW Change 0%	HW Change 5%	HW Change 10%
1101			16.50	26.93	196.30	343.54		
1115		11.36	1.18	1.38	36.79	176.05		
1221						229.73		6.56
2110			6.35	16.53	13.43	54.89	6.51	2.65
2111	0.99			5.36	82.72	115.74	0.13	0.10
2112						1.99		
2113				0.71		16.38		

Table 3

Total Area of Hardwood Recovery in Post SOD Tanoak and Mixed Tanoak Forests

VEG2014 Type	HW Change -5%	HW Change 0	HW Change 5%	HW Change 10%	HW Change 15%	HW Change 20%	HW Change 25%	HW Change 30%
1102	8.45	147.82	12.22					
1104	74.15	494.13	15.71					0.62
1116		47.45	15.58					
1211		5.49		8.18				
1212	2.75	864.68	495.78	92.98	26.34			
1216	12.10	629.17	417.86	109.64				
1217	3.72	338.26	21.69	4.53				
1222	18.57	3005.98	42.92	1.05	0.22			3.72
1224		47.10						

Table 4

Total Tanoak Loss Since 2004 (measured in acres)

VEG2014 Type	Tanoak Loss
1102	168.48
1104	584.61
1116	63.03
1211	13.68
1212	1482.53
1216	1168.78
1217	368.20
1222	3072.45
1224	47.10
Total:	**6968.86**

Table 5

Total Coast Live Oak Loss since 2004 (measured in acres)

VEG2014 Type	Coast Live Oak Loss
1101	583.27
1115	226.76
1221	236.29
2110	100.37
2111	205.03
2112	1.99
2113	17.08
Total:	**1370.79**